Responses of certain fishes and snakes to sound[1]

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(*With three figures in a plate*)

Very little work has been done on the hearing capacity or mechanism of the lower vertebrates in India. Earlier workers like Kreidl (1895) believed that fishes were deaf or, at best, could receive some vibrations through cutaneous sense. Only after Bigelow (1904) and others, was it proved conclusively that fishes do perceive sound.

In fishes, in addition to the inner ear, the lateral line system perceives both the displacement of the medium and near field sounds of low frequency range (Harris & Van Bergejik 1962; Tavolga 1971). It is thus obvious that the hearing mechanisms in lower vertebrates differ vastly from those of man and other mammals, and a comparison of the different hearing mechanisms could be of special interest. While it is known that some of the lower vertebrates have the capacity to hear air conducted sounds, it is said that snakes perceive sounds by bone conduction (Tumarkin 1968). Eventhough there are some inconclusive reports and concepts on the hearing capacity of ophidians, scientifically proven studies are wanting as obvious from the review of hearing mechanisms in vertebrates by DeReuck & Knight (1968). Hence, in this study, an attempt is made to evaluate the hearing capacity of a few fishes and snakes of South India.

MATERIALS AND METHODS

Four species of teleost fishes namely *Rhinomugil corsula* (Mullet), *Tilapia mossambica* (Tilapia), *Anabas scandans* (Indian Climbing Perch) and *Cyprinus carpio* (Common Carp) and the following snakes: *Ptyas mucosus* (Rat Snake), *Argyrogena fasciolatus* (Banded Racer), *Boiga ceylonensis* (Ceylon Cat Snake), *Eryx johni* (Sand Boa) and *Ahaetulla nasutus* (Green Whip Snake) were used for this study. Of these snakes, *Boiga ceylonensis* and *Ahaetulla nasutus* are mildly poisonous snakes (Rajendran 1968; Smith, Malcolm A. 1942).

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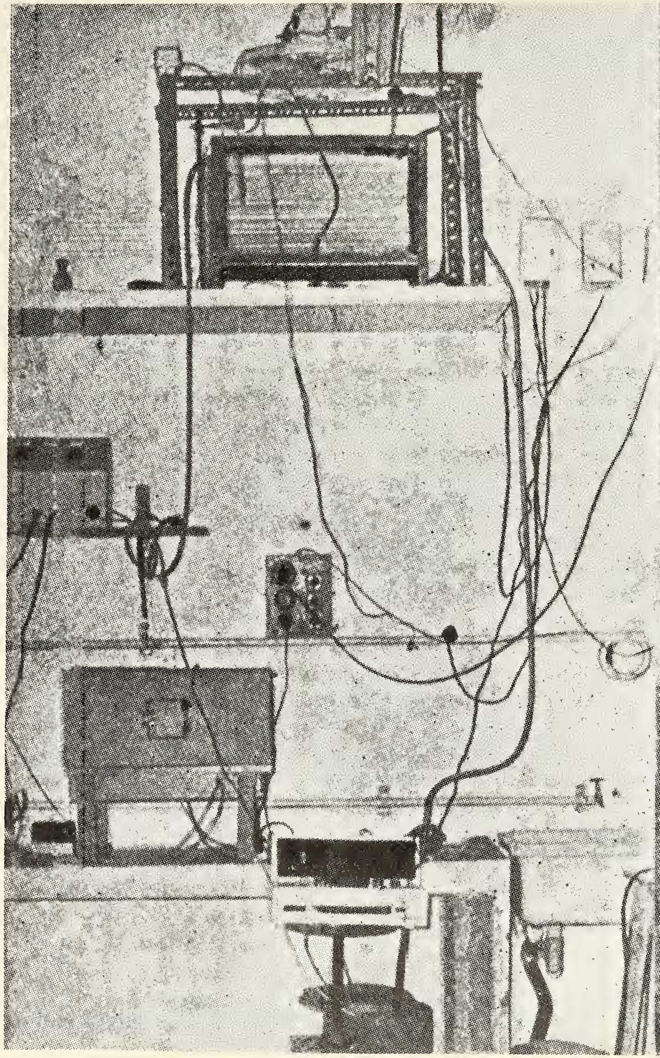

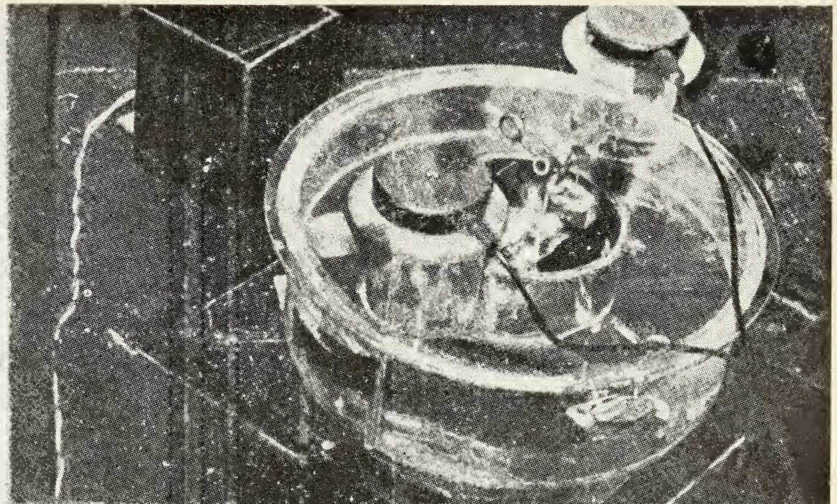

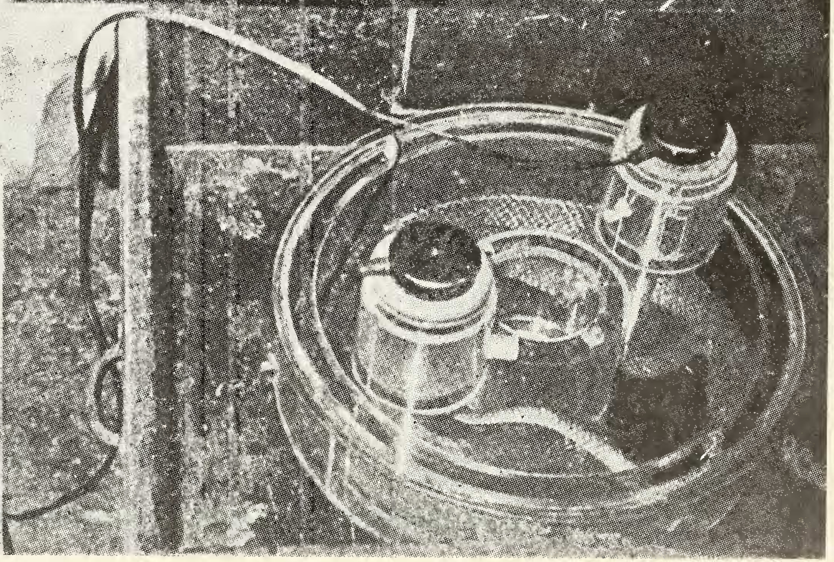

Left—Fig. 1. General experimental set-up showing the activity chamber, electronic counter, the water recirculation system (for fishes) and audiometer. *Right above*—Fig. 2. Annular activity chamber showing experimental fish (*Tilapia mossambica*) inside and the connecting ear phones from the audiometer. *Right below*—Fig. 3. Activity Chamber with the snake (*Ptyas mucosus*) inside.

An audiometer (Manufacturers: Bharat Electronics Limited, Bangalore) with pure tone and speech audiometry was used for this study along with an activity chamber modified by Kutty *et al.* (1971) connected to an electronic counter (Fig. 1).

The experimental animal was left inside the transparent plastic annular activity chamber and the two ear phones of the audiometer with rubber pads were snugly fitted to the two top wells of the chamber. This unit was kept inside a wooden box to shut off external light and disturbance. A peep hole covered with a one way plastic viewer, was used for observing the animal. The inside of the box was lighted from above. There was provision for measuring the random activity of the animal when it moved round the chamber. This was facilitated by focussing two beams of light (directed from outside of the chamber) on two photocells fixed in the inner hollow of the annular activity chamber. When the animal moved and cut the beam of light the event was counted and a record of the activity per unit time was made.

In the case of fishes the activity chamber was filled with water leaving an air column at the top of the wells (Fig. 2) and there was provision to flush the chamber with fresh water continuously by means of a circulatory system. As for snakes, the animals were left in the chamber as such and their activity observed (Fig. 3). In addition to random locomotary activity of the animal, other behavioural changes were also observed and recorded.

Results and Discussion

Fishes

All the four species of fishes tested responded to pure tones. Different behavioural changes were observed in the four species. Behavioural changes taken as responses to sound were changes in locomotor activity and eyeball movements. Locomotor activity and eyeball movements were counted respectively by the Electronic Counter and visually in an undisturbed condition (control). Various frequencies of sound were fed to the annular chamber through the ear phones and the intensity of the sound was increased stepwise every 10 dbs and changes counted and analysed. In the case of Mullet, its random locomotor activity increased when subjected to the sound as could be seen from the data given in Table 1.

Table 1

Responses (Changes in Locomotor Activity) to Sound in *Rhinomugil corsula*

Mean weight: 35.5 gm — Water Temp.: 25°C
Mean length: 16.5 cm — Room Temp.: 27°C

Frequency c/s.	10 dB.	20 dB.	30 dB.	40 dB.	50 dB. and above
125	—	+	+	+	+
250	—	+	+	+	+
500	—	+	+	+	+
1000	—	+	+	+	+
1500	—	—	+	+	+
2000 and above.	—	—	—	—	—

+ Increase in Locomotor activity from control. — No increase from control.

As can be seen from the Table, Mullet, which is a non-ostariophysid in which Weberian ossicles are absent can perceive frequencies upto a maximum of 1,500 cycles/second only and the hearing threshold was found to be about 20 dB. The lateral line system helps in perceiving only low frequency tones. This finding is in conformity with that of Maliukina (1960).

Anabas scandans and *Tilapia mossambica*, the two other species of fishes did not show any significant change in locomotor activity and hence other behavioural changes like movement of the eye balls were studied in both these species. The rate of movement of the eye balls was found to be lesser when they were subjected to pure tones of various frequencies. Hearing response in *Anabas scandans* is shown in Table 2.

Table 2

Responses (Changes in rate of eyeball movements) to Sound in *Anabas scandans*

Mean Weight: 26.5 gm — Water Temp.: 25°C
Mean length: 10.5 cm — Room Temp.: 27°C

Frequency c/s.	10 dB.	20 dB.	30 dB.	40 dB.	50 dB. and above
125	—	+	+	+	+
250	—	+	+	+	+
500	—	+	+	+	+
1000	—	+	+	+	+
1500	—	+	+	+	+
2000	—	—	+	+	+
3000	—	—	+	+	+
4000	—	—	+	+	+
6000 and above	—	—	—	—	—

+ Decrease in Eyeball movements from control. — No decrease from control.

From above it is obvious that as regards frequency discrimination *Anabas scandans* can hear frequencies upto 3,000 c/s, threshold of intensity for the various frequencies being 20 to 30 dB. This is similar to the observation that ostariophysids which have a swim bladder connected with the internal ear by means of a chain of ossicles known as Weberian ossicles, perceive high frequency sound (Enger 1968; Tavolga 1971). The fish *Anabas scandans* has an accessory respiratory organ known as the labrynthiform organ—an air pocket in the head, which functions similar to the swim bladder of the ostariophysids, aiding in auditory functions. The sound converted as pressure wave touching the fish is amplified by the swim bladder or any other air pocket in the fish. In spite of this the non-ostariophysids are also able to perceive sound frequencies though at a lower level. Behavioural study in response to pure tone transmission in *Tilapia mossambica*, further confirmed that the hearing in non-ostariophysids is limited to the low frequencies as shown in Table 3.

Hearing responses of a typical ostariophysid, the common carp *Cyprinus carpio* is shown in Table 4.

It can be seen that these fish responded very well upto frequencies of 4000 c/s the highest range of hearing capacity among all fishes studied.

TABLE 3

RESPONSES (CHANGES IN RATE OF EYEBALL MOVEMENTS) TO SOUND IN *Tilapia mossambica*

Mean Weight:	30 gm	Water Temp:	25°C
Mean Length:	12 cm	Room Temp:	27°C

Frequency c/s.	10 dB.	20 dB.	30 dB.	40 dB.	50 dB. and above
125	—	+	+	+	+
250	—	+	+	+	+
500	—	+	+	+	+
1000	—	+	+	+	+
1500 and above	—	—	—	—	—

+ Decrease in Eyeball movements from control. — No decrease from control.

TABLE 4

RESPONSES (CHANGES IN RATE OF EYEBALL MOVEMENTS) TO SOUND IN *Cyprinus carpio*

Mean Weight:	37 gm	Water Temp:	25°C
Mean Length:	18 cm	Room Temp:	27°C

Frequency c/s.	10 dB.	20 dB.	30 dB.	40 dB.	50 dB. and above
125	—	+	+	+	+
250	—	+	+	+	+
500	—	+	+	+	+
1000	—	+	+	+	+
1500	—	+	+	+	+
2000	—	—	+	+	+
3000	—	—	—	+	+
4000	—	—	—	—	+
6000 and above	—	—	—	—	—

+ Decrease in Eyeball movements from control. — No decrease from control.

A study of the 4 species of fishes confirmed the view that ostariophysids have a better hearing range than the non-ostariophysids. But the threshold of hearing was about the same (20 to 30 dB) in both ostariophysids and non-ostariophysids. It appears that the ostariophysids possess the lowest auditory thresholds and highest upper frequency limits. This is undoubtedly a function of the Weberian apparatus which couples the auditory signal received by the swim bladder to the inner ear in a manner analogous to the operation of the middle ear ossicles in man. Other air chambers can serve a similar fashion as the branchial cavity in the labyrinthine fishes (Schneider 1941) and as shown in the case of *Anabas scandans.*

Snakes

None of the snakes responded to pure tones. However, all of them responded to music both instrumental and drum, fed to the activity chamber through an audiometer at 50 and 100 dB intensities. The results are shown in Table 5.

Ptyas muscosus (Rat Snake) when exposed to the music of predominant low frequency tones at 100 dB, the visible normal respiratory